EXECUTIVE SUMMARY

Background

Water resource managers, water demand managers and water infrastructure planners alike, are faced with an acute lack of knowledge regarding on-site household water use as additional water source to potable Municipal supply. The most common on-site household water sources (HWS) of this nature include:

- groundwater abstraction by means of garden boreholes or any other type of groundwater abstraction point (GAP)
- rainwater harvesting systems (RHS) that gather water from rooftops
- greywater reuse (GWR).

Greywater, rainwater and groundwater as sources of free water available to every homeowner onsite have been noted in the past elsewhere (Milne, 1979), but this is the first research in South Africa into these water sources at household level.

Problem Statement

The nature and extent of HWS-application by individual water users in residential areas impacts on all infrastructure elements of the water supply and waste cycle. Application of a HWS creates an apparent load reduction on piped reticulation systems, treatment works and on water resources. Unfortunately HWS are often neglected during urban and resources planning exercises. A critical question is addressed by this research, "To what extent and in which way could water demand and wastewater flow be influenced by the application of these on-site sources?"

Key Objectives

This research project addressed the matter at a strategic level with the following key objectives:

- to strategically assess the status quo of HWS, with a focus on the Western Cape by means of a desk-top review
- conceptually describe an end-use model incorporating HWS and assess the theoretical impact of HWS on the average annual daily water demand (AADD)
- identify trends and future research needs
- summarise the knowledge gained, describe the HWS model and document key findings.

Legal implications with regards to HWS application

At household level in serviced areas consumers typically obtain water from a water service provider, which is normally the local municipality. With ever increasing water tariffs and water restrictions consumers frequently make use of HWS, or try to do so. The legal status of the use of these resources is contained indirectly in the National Water Act (NWA) (Act No 36 of 1998) and to a limited extent also in the Water Services Act (WSA) (Act No 108 of 1997). Despite HWSs not being dealt with directly in the NWA or the WSA, it could be concluded from this study that HWSs for domestic purposes in a serviced area could be deemed "legal" in the general case. No registration of the particular use is required, unless a municipality has followed procedures by which by-laws have been put in place, thus regulating the registration of such use – in such a case a home owner may be required to register use of a HWS, with consequences if not registered.

Groundwater abstraction

A groundwater abstraction point (GAP) may be for example a well-point, garden borehole or a shallow well. The cost of installing a GAP varies greatly depending on the GAP-type and geology, but it could be concluded that GAPs are relatively expensive to install. One GAP on a residential property could easily supply the entire average annual water demand (AADD) for a property based on estimates for the yield from this preliminary work and the most recent empirical guidelines for AADD. However, due to plumbing complexities and water quality concerns GAPs are commonly used exclusively to meet outdoor needs, mainly garden irrigation. Groundwater use seems to be relatively common in residential areas of the Western Cape today, but incidence is limited to low-density high-income areas. Analysis of the data for Cape Town suggests that about 15% of residential properties with area exceeding 1000m^2 registered a GAP during the water restriction period of 2003-2004. Presuming that only half were registered at the time, the incidence of properties with GAPs could easily be about 30%. Previous research in Pretoria (Simpson, 1990) estimated that 38% of properties in the study area in Pretoria had GAPs – a similar finding at the time. This relatively large percentage of properties with GAPS combined with the relatively large yield from GAPs is expected to have a notable impact when AADD analyses are performed on municipal water meter readings, such as with recently published AADD-guideline studies (Jacobs et al., 2004; Husselman and Van Zyl, 2006; Van Zyl et al., 2008). Consumers artificially reduce the consumption from the municipal water distribution system (WDS), leading to under-estimates for AADD.

Rainwater harvesting

Rainwater use seems to be uncommon in residential areas of the Western Cape today, mainly due to the relatively high cost of storage tanks, the negative visual impact of rainwater harvesting systems and, most importantly, the fact that the high-demand summer period corresponds to the dry season in the Western Cape. It is apparent from information gained during this study that rainwater use is more prevalent in other areas of the country, for example the central Karoo, where the negative seasonal effect is less pronounced. As is the case with groundwater, gaining knowledge about the presence of rainwater use is often hampered by uncooperative home owners. In contrast to GAPs, it is relatively easy to obtain theoretical estimates of the volume (yield) from a RHS. Theoretical estimates of the available yield are a function of the impervious area (typically the roof), storage tank size and rainfall. Houses in low density residential areas in the Western Cape are generally not limited with regard to catchment area (relatively large roofs), but tank yield during summer months when the water is needed is low. In contrast, houses in high density residential areas are limited due to catchment area (small roofs), and therefore can only yield low volumes of rainwater. This study suggests that the financial benefits of a RHS are limited and households would typically reimburse the initial capital expenditure after many years only. In agreement with this study financial analysis by Ward et al. (2008) revealed that RHS of smaller domestic systems are not particularly viable in the UK. However, from a water conservation point of view, notable potential water saving can be achieved via implementation of RHSs, despite the poor financial incentive.

Greywater reuse

Grobicki and Cohen (1999) provided results regarding the projected impact of water reuse on urban water demand in South Africa a decade ago, but their work did not address on-site household reuse. This study earmarks residential on-site greywater reuse as a contentious yet promising alternative water source to urban communities, particularly in the low-density high-income suburbs where health concerns are less pronounced and the generation rate is notably higher than for high-density townships. Greywater reuse is economically viable if not treated in any way. However, when treated and disinfected prior to reuse the product water becomes relatively expensive and the option is less attractive financially.

The required greywater reuse quality is discussed by Jackson and Ord (2000) for reuse in the UK, and it is suggested that the water standard meets the UK's bathing standards if it is used for toilet flushing. When it is used for irrigation the natural rate at which pathogens die off when exposed to the natural environment (e.g. when wastewater is used for irrigation) is a valuable safety factor and is encouraging for reuse of greywater for garden irrigation.

The volume of water available from greywater reuse is relatively small compared to groundwater sources.

Yield of household water sources

The greywater generation rate of a typical suburban property considered for analysis in this study is about 280 ℓ/stand/d and is significantly less than the typical yield from GAPs. The yield from RHS in the Western Cape winter-rainfall region is even less and, considering a realistic tank size, RHS are not useful to meet garden irrigation demands. A typical GAP-yield of 1000 ℓ/h seems to be the "best guess" based on this knowledge review and data from the Western Cape coastal areas. A yield of 1000 ℓ/h is considered to be relatively high in relation to the garden irrigation demand for most typical gardens. If a garden were irrigated for say one hour per day the daily abstraction would be 1000 ℓ/d. This is in agreement with other reports of GAP abstraction in the range of 1000 to 2000 ℓ/d. It could thus safely be assumed that a property with a GAP would meet 100% of its garden irrigation demand from this source and no other HWS would be needed in combination with a GAP to meet garden irrigation demand.

Estimated impact of HWS on water demand

This research suggests that broad and extensive application of HWS in a relatively low-density residential area could lead to a reduction of as much as 40% in the AADD. This is a significant fraction and the corresponding impact on the WDS and sewer system could be significant. An upper limit of about 40% reduction in AADD (water saving) was reported after analysis of water use in Cape Town (Jacobs et al., 2007) and is also in broad agreement with savings reported elsewhere. A 46% saving was achieved during drought conditions in California (Loaiciga and Renehan, 1997) and a saving of up to 50% is reported by Hunt et al. (1998) for gardens that are extensively xeriscaped.
A reduction of up to 40% in residential water use could thus be expected if HWS were used at all properties to meet outdoor water needs. This statement is based on the assumption that the initial status of users' gardens would be similar to the pre-water restriction state of users in the Cape Town study reported on by Jacobs et al. (2007).

Typologies and Trends

It is clear from this study that strategic capability cannot be viewed in a static way. What customers value varies with time and the use of water is no exception. At some periods in time certain water sources are valued more highly than at other times. The following typologies and trends could be identified based on this research:

- once a HWS is in use it typically remains in use long after the "need" for it (say to carry the user's garden through a period of water restrictions) has passed
- groundwater use is the only notable HWS in terms of penetration and available volume
- the preliminary results from this study suggest that anything from 0% (no groundwater) to 60% (typical upper limit) of users in a particular suburb might have access to groundwater via some type of GAP, with 30% of low-density users with access to groundwater considered typical in Cape Town
- the yield from a typical GAP is about 1000-2000 ℓ/d and is considered to be relatively high compared to other HWS yields and to water demand of residential properties
- rainwater harvesting is heavily influenced by spatial aspects, with some regions finding RWS uncommon (Cape Town metro) and others viewing it as an essential part of water supply (e.g. DWAF-sponsored RHS projects for low-cost housing units in the arid Karoo)
- RHSs were commonly employed locally in days when supply to urban dwellings was unreliable or not available; since the inception of reliable municipal WDS in urban areas of South Africa about 4 decades ago the use of rainwater tanks has become less prevalent
- in most regions of South Africa rainwater tanks are relatively low-yielding and are not viable from a financial viewpoint of the home owner
- on-site greywater reuse in serviced municipal areas is considered to be a relatively new trend; this study reports that greywater reuse as HWS is relatively uncommon, is a contentious issue in terms of community health (Barnes, 2006) and should arguably not be encouraged on a large scale until further research has been conducted with regards its wider impacts on health.

Discussion and Conclusion

The commissioning of a HWS by a private home owner is often drought-driven. This study confirms findings from previous reports that water restrictions/droughts are the main driver behind HWS application. When installed the HWS typically remains in use, even after the water supply situation via the WDS returns to normal. Given a sufficient and relatively inexpensive supply of water from a municipal source few users consider HWSs. However, there seems to be a developing trend where consumers with a concern for the environment use HWS merely to be "green" – despite poor economical returns. The only HWS found to have notable incidence during this study is groundwater use. Probing studies performed as part of this work show that 15% of low density residential properties in Cape Town registered a GAP during the water restriction period of 2003-2004, but the actual incidence of GAP is expected to be closer to 30% (findings during a Hermanus case study reported in this research pointed towards similar levels). The use of GAPs as a HWS in the Western Cape is relatively common. Previous research in Pretoria (Simpson, 1990) estimated that 38% of properties in the study area in Pretoria had GAPs at the time, with a maximum of up to 60% incidence in some areas. In the few reported cases where GAP yields could be estimated, the delivery of water from the GAP is notable – often meeting all garden irrigation demand. The use of RHSs and greywater reuse systems are significantly less common and produce notably less water than GAPs.

Climate change would influence the yield of GAPs and RHSs, but should have little impact on the greywater generation rate. The possible impact of climate change on HWS, and particularly water use from GAPs, has not been investigated as part of this study and is clearly a future research need.